Description of pictures
for handout Week4-1.pdf

Pictures and their descriptions are from a book:
Bathe, Greville An Engineer's Miscellany, Patterson&White Company, Philadelphia, 1938
The style is kept unchanged.

Fig.1

The Copper Forge - from a book published in 1629 by Octavius da Strada. On the title page of Strada's book may be found the following description of its content:

   Ingenious drawings of all kinds of Water - Wind - Horse and Hand mills including good looking and useful pumps, also other machines for raising water aloft, also lusty wells and water works, the like of which has never yet been seen: these augmented with still other inventions of various kind.

A copper-smithy in which by means of a water wheel both hammer and bellows are driven. Explanation of the letters of this figure:
A the hammer,
B the copper which is made glowing hot at the hearth
C the water wheel
D the axle of the water wheel
E the crank which gives the pull of the bellows
F-G the arm whereby through the pole
E-F the beam G-H is pulled around
I-K-L-M-N a cross which is entirely fast in the middle and which can be moved in K and L
O-P the bellows
Q the hearth
R the short arm at the axle which lifts up the hammer
S-T are two posts between which the hammer is supported and is movable in S and T.

In Fig. 3 a blade mill is shown with a workman sharpening a gigantic spearhead; the power is derived from a horse "or other sensible animals" working a drag mill. A small corn mill is shown at the upper right of the engraving, which grinds the animal's feed at the same time that its master's cutlery is ground. The translation of the text for this illustration reads:

   This is a horse mill with an attached blade mill, and on the upright axle tree there is a horizontal comb wheel to which there is a trylles and an upright comb wheel connected. The latter drives around a trylles fasten to the millstone. On the axle of this comb wheel there is fastened a large disc which by means of a twisted rope drives another disc around on whose axle is fastened a grindstone and since the figure is quite understandable without it, lettering on the figure has been omitted.

A primitive boring machine is shown in Fig. 4. An energetic man works a crank by means of a long lever and a link. The fly wheel shown at the lower end of the crankshaft is made of wood with several lead weights cast into holes previously bored near the rim to add momentum. The text says that this is a kind of boring machine where pipes are bored.
This is a boring machine on which all kinds of wooden pipes are drilled, which is driven by a crank. Attached to this crank there is only a trylles which engages with a comb wheel on the axle of which another trylles is fixed which engages with two cog wheels upon which the drills are fastened. The wood, which is drilled, is pulled towards the borers by a weight. Which may be satisfactorily perceived from the figure with the aid of a little intelligence.

The foregoing explanation states that wooden pipes are being bored, but it would seem obvious that they are gun barrels as used on the early German wheel lock rifles (30-36 inches long). A barrel in he foreground resting on the table shows a hexagon or octagon breech end, a not uncommon characteristic of these early firearms.

In Fig. 5 the machinery of a saw mill engaged in cutting a log into wide boards is illustrated. The two men standing at the cradle are, by means of levers, guiding the log as saw progresses through the wood. The forward travel of the cradle is automatically contrived by means of a rope and ratchet wheel that is moved intermittently by the saw frame. The text to illustration reads:

This is a kind of saw mill driven by a large wheel, to which certain driving works are fastened as can be seen and the saw is pulled up and down by means of the crank, in which manner the wood may be cut, drawn along with a rope, and the ratchet wheel moves ahead every time. This among the other things is shown by the figure and there is no need to describe it any further.

In this brief description of a saw mill no mention is made as to the power used to drive it, but from the pair of legs barely observable inside the tread wheel, it is obviously man-powered. In addition to the freeman, who was willing to perform the role usually assigned to animals, the use of prisoners of war, as well as jail birds, was quite commonly resorted to for such tasks. In the example before us, the detached indifference of the master sawyers to the man treading the wheel might well suggest such an unfortunate situation.

Some observance must be made on the gearing of the tread wheel to the crankshaft; only one pair of engaging gear wheels could be used at one time. One set of wheels would probably double the speed of the crank while the other would halve it.

Another saw mill with the addition of a timber hoist worked by a ratchet wheel from the saw frame is shown in Fig. 6. The explanation to this engraving says:

This is a saw mill driven by water, and let A be the water wheel to which a crank with an upright piece of wood or a pole B to the top of which a saw C is fastened which is a mechanism which can not be seen here, but which drives ahead the rack K, which runs on rollers. Every time the wood has to be laid directly before the saw a little bit further by the ratchet wheel D, so the each time the pole E drops one tooth forward, and the latter is fastened in H and in I (with enough room to let them move freely). The ratchet wheel with its axle tree or roller F is only for pulling up or laying down the wood. It has likewise a pole fitting in the ratchet which latter is wound up from without along with its axle (wherefore the rope tied to the wood winds up). Just how this takes place is shown at H and this then is a short account of this saw mill.

This type of power saw driven by water dates authentically from about 1322 and was first used near Augsburg in Germany. As early as 1635, saw mills were introduced into the New England's Colonies. One is mentioned at this time as being at Salmon Falls on the Piscataqua River near Portsmouth in New Hampshire. The power driven frame saw held its own, where there was unlimited water power, until about 1825, when the circular saw began to be used in conjunction with the steam engine, which allowed saw mills to be built anywhere adjacent to the forest lands.

The engravings in Pict.7-10 are from Encyclopedie, ou Dictionnaire Raisonne des Sciences, des Arts et des Metiers, par Une Societe de Gens de Lettres. Denis Diderot et Jean le Rond D'Alembert, Paris and Neufchastel, 1752-1780.
In Fig. 7 is shown the interior of a small engineering workshop. On the right at b is a turner using a hook tool on a piece of iron shafting. The labor of turning large pieces in the lathe by hand required not only skill but also endurance, as any slip of the tool spoiled the finish of the work. This hand turning method was universal until the advent of the slide rest into general use some time after 1800. The power to drive this lathe is furnished by means of "the great wheel" turned by hand. The man operating the crank might possibly exert the equivalent of one eighth of a horse power for a short periods, and this system of obtaining rotary power emphasizes clearly more than anything else what a great boon the advent of the steam engine was to the small manufacturer. At a in the rear of the workshop is a man turning wood on a pole lathe which operates as follows: a rope fixed to the treadle is wound once around the piece to be turned (between two centers) and is then attached to the spring beam at c. By pressing down the foot a few revolutions of the work were made towards the turner who applied his tool quickly, removing it at the same time he released the pressure of his foot. The spring then drew up the cord ready for the next few cuts. The pole lathe is of such antiquity that it is hard to hazard guess as to when it was first used. The credit for this invention is given by Pliny the Elder (Plinius Secundus 23-79 A.D.) to Theodorus of Samos, but Diodorus Siculuis, the historian, places it at a very remote period of time, as far back as B.C. 1249 Virgil (Virgilius Maro B.C. 70-19) in his works several times mentions "torus" as meaning a turner's wheel or lathe. In ancient days the lathe was only used for turning wood, ivory and bone, and was probably adapted originally from the potter's wheel.

On the left side of Fig. 7 at d is a traversing mandrel lathe for chasing short screw threads such as are to be found on optical instruments. This lathe is also revolved by the spring beam, but the cord is pulled down by hand for the better control over the tool while chasing the thread. The four square wedges observed in the side of the headstock lock the thread dies that engage with the corresponding master threads on the lathe mandrel. Four differently pitched screws can thus be reproduced as the mandrel turns and also progresses forward, controlled by the particular die selected, which is held fast by one of the wedges.

In Fig. 8 nailmakers are shown at their work. The tedious repetition involved in this craft is well known. But little ingenuity was ever displayed by the early nailmaker to evolve any specialized machinery to increase his output and reduce his labor. The small wages paid to workmen on a piece work basis probably prevented any change in this direction. The making of small brads and tacks in quantity presented the greatest difficulty, and hand labor was not generally displaced until the year 1795, when Jacob Perkins of Newburyport, Mass., invented a machine which was capable of turning out brads at the rate of 200,000 a day.

The taillandier or tool maker's shop is shown in Fig. 9. Here the engraver has managed to convey very realistically the work in progress. At the right is a workman chasing down the threads of a large screw for a press, on a traversing mandrel lathe. The work is first turned to size by the help of "the great wheel" belted to the chuck pulley at m. Then turner engages one of the three wedges shown in the side of the headstock with the threads of the master screw on the spindle of the pulley m, and by using his foot as in the
pole lathe he turns the thread to the correct depth, the pitch being the same on the work as
the traverse of the master screw in its bearings. At the right hand side of this engraving a
man is cutting a box screw for a leg vise by turning a bar which has cut on it the master
thread. A square ended tool fixed in a rest shown between the two bearings at the far end
of the lathe, cuts a corresponding screw on the blank.
While the cutting of threads represents only a very small part of the toolmaker's art, yet it
was one that presented so much difficulty that only quite short screws could be made
with any fair degree of accuracy, certainly not more than two feet long. The first lead
screw for a lathe of any considerable length is credited to William Buckle in about 1825,
at the Soho Foundry, Birmingham, England, but undoubtedly ingenious and skillful
mechanics had at a much earlier date than this produced long iron screws, solely with
such simple tools as a hammer, chisel and file. Screws made of wood are very much
older, for screw presses for wine and oil were used in early Roman times. Archimedes of
Syracuse (BC 287-212), who is generally credited with the invention of the spiral tube for
elevating water, also devised a screw or helix for launching ships. As it has already been
shown, the lathe used for the turning and finishing of heavy parts is of so recent a date
that the early artisan did not considered any kind of work that required precise
machining. The working or rubbing faces of castings, etc., were chipped and filed to a
fair surface and then sometimes ground with fine sand and water or emery powder. This
latter material perhaps was the mechanic's most faithful friend for it helped to smooth out
the irregularities that his imperfect equipment could not cope with otherwise.

The two fundamental metal crafts which have been in existence from the earliest times
were founding and forging, but in so limited a degree that carpentry work constituted
most of the early millwright's art. Wood was employed wherever possible, as for the teeth
of gearing, axles, shafts, pumps, wheels, bearings, and a host of other mechanical parts
now made exclusively of metal. Only in 1776, at the Albion Flour Mills in London, were
iron gear wheels and axles used for the first time, and were considered then very
advanced engineering. It was not until thirty years later that American mills were
equipped with such cast iron gearing by Oliver Evans, about the year 1806.
In Fig. 10 the inside of large forge is shown. Here again is found the inevitable tilt
hammer, but on a larger scale. Even at its best this method of forging was deficient
because there was a limit to which the hammer head could be raised. In fact, the larger
the work the shorter and weaker was the blow. The forging of ship's anchors represented
the largest class of work ever tackled by the artisan of the eighteenth century. The shank
of the anchor alone often contained from three to thirty five separate pieces of bar iron
according to the size required. All of these had to be welded into as solid a whole as
possible.